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The Materials Division: A Case Study

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THE MATERIALS DIVISION: A CASE STUDY

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This presentation is a review of the efforts of the Materials Division at NASA's Lewis Research Center to evaluate the quality of the Division's output and use that evaluation to improve performance. A brief description of the Division will be presented which will be followed by a discussion of the steps taken to improve the quality of our output and evaluate the effectiveness of those steps.

The Materials Division's Branches as well as the broad spectrum of technical disciplines which the organization encompasses are shown in figure 1. With about 190 direct staff (approximately 105 C.S. plus SSC, on-site university, industrial guest investigators, NRC post-doctoral fellows, etc.) and only 16 managers, the span of control is rather broad. In addition, segments of Branches are located in different buildings expanding the problems of direct supervisor/staff interaction.

The Division's job stretches from generic, rather basic research and modeling aimed at new understanding of barrier problems to the identification of new materials and processes (fig. 2). All of this creates new materials options for NASA and the aerospace industry to apply toward our very challenging future missions and commercial/military propulsion and power systems. Some of these results are focused on more mission-specific materials needs such as very high performance aircraft turbine engines or large space power generators. In selected cases, an ongoing flight project requires direct materials support when a problem arises in fabrication or hardware performance. In such instances, the full theoretical background and experience of the Division can be focused to get a rapid, feasible solution.

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The complex relationships our Center has with its customers and which we, as a microcosm of the Center, also have is displayed in figure 3. Basically, we have these three sets of customers: our Headquarters offices that provide the direct funding via interaction with the executive and legislative arms of government; our government customers - both within NASA and beyond - who use our technology to enable enhanced mission performance; and our industrial customers who take pieces of our work and adapt them to commercial systems. In addition, as a research laboratory, we have peers for whom we also provide scientific understanding, new ideas, and reports.

It is important to continually interact with our customers. Based on their inputs and our own creativity, we couple key national needs and opportunities. Plans are formulated to pursue these needs but by the time specimens are fabricated, test capability set up and checked, etc., several years can go by. Thus, the needs themselves or the people who articulated them may have moved to other organizations. For this reason, continuing feedback and discussion is necessary to close the loop (shown in fig. 4).

Figure 5 compares the different measures of success faced by our researchers versus our technologists. Different customers have different needs. The research customers base success on new ideas and publications. A continuing flow of these useful contributions is important. For our technology customers, success is the timely delivery of concepts that can be used, i.e., converted into tools or hardware for a reasonable additional investment.

We identify some of the efforts we have made to better meet all of our customers needs in figure 6. In the subsequent figures, we will try to provide examples of the approach and results.

An approach taken to see what our industrial customers really valued and what they felt we needed to work on to satisfy their future needs is shown in figure 7. The results, of course, are proprietary to each company. However, some things we gave low priority were viewed very highly by industry. This feedback caused us to rebalance part of our work and our resources.

Figure 8 shows the results of a nonparticipative edict in 1983 when this present management took charge of the Division - "Shift reporting to peer-reviewed journals" rather than publishing in NASA internally reviewed reports which have a more limited distribution. Journal articles doubled and have remained a substantial fraction of our output of reports, conference proceedings, book chapters, etc.

To go beyond just report quantity, we instituted our pilot effort to assess report quality and developed the framework shown in figure 9. Note the quality of the research and the potential impact on NASA needs combine to be predominant factors rather than being concerned only with the writing clarity, etc.

The evaluation of these reports by both the first line supervisor (Branch Chief) and by Division management (Deputy Division Chief) are reasonably close. A plot of the scores is shown in figure 10. If a major disagreement arises, a third party (the Division Chief Scientist) also evaluates the report. Figure 11 shows the distribution of scores since we started this process in 9/87. The preponderance of reports rate very good to excellent. Figure 12 shows a very slight trend upward in scores. We will continue to foster improvements and yet need to be alert to "grade creep."

We are also working to upgrade the technical skills of our staff. One aspect has focused on hiring with graduate training. Figure 13 shows the heavy concentration of MS and PhDs hired since 1983. These figures, of course, reflect both C.S., and SSC hiring.

Once hired, we are working to better mentor our new people. Our recently developed formal approach to mentoring is shown in figures 14 to 16. To date, it is too early to judge the results but we feel we're moving in the right direction.

Discussion topics related to career review were formalized on a division-wide formal basis in 1989 (although many of these topics always have been covered informally). Here we are trying to get the issues discussed that relate to actions that the individual and management must take to help each

person move their career in the direction that they want it to go. The form used as a guideline for these discussions is presented in figure 17.

To move toward better management, we've been surveying our staff for over 5 years as to how they felt about Division management. The form used is shown on figures 18 and 19. Basically, we ask them to anonymously rate the two of us overall, and on the three major strategic growth directions the Center is pursuing. The only identifier is the Branch Code so we can spot any local trouble or organizational-specific issues. We also ask for additional input as to how things are going from their view. We then tabulate all the data, summarize it by Branch, and have a feedback session where we discuss the problem areas and what we will try to do to improve.

A similar questionnaire that was developed in 1988 for the staff to rate their immediate supervisor is reproduced as figures 20 and 21. Again, the inputs are anonymous. One, noninvolved secretary collects all the responses, tabulates the data, lists all the comments separately (so scores and comments are not tied together) and gives me the floppy disks. Then she destroys the original forms. While we lose somewhat in not being able to correlate score and comment, the preservation of anonymity is essential. The results were very positive. A few managers got some specific areas to work on and in general we were told we need more focus on better soliciting staff input.

Figure 22 reflects that Lewis Materials Division is among the top organizations in the U.S. We will not be satisfied with that, however - we will continue efforts to be the top.

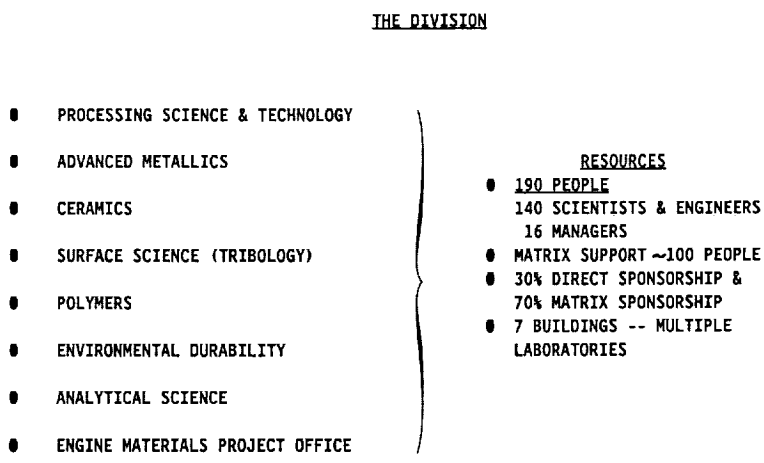


FIGURE 1.

THE MATERIALS DIVISION -- A BROAD PROGRAM OF R&T

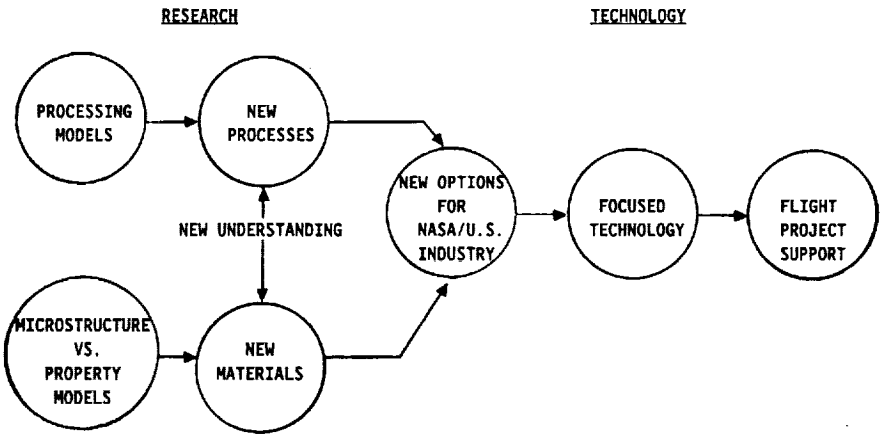


FIGURE 2.

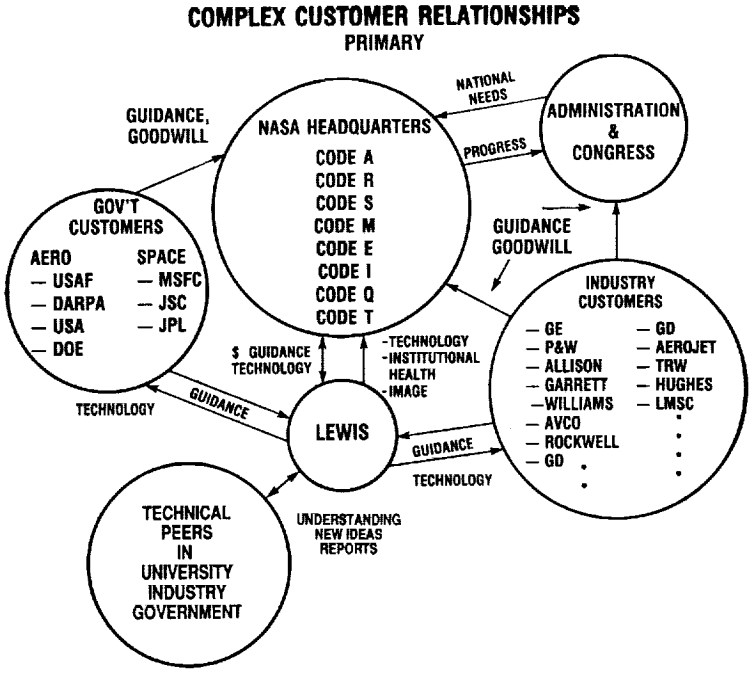
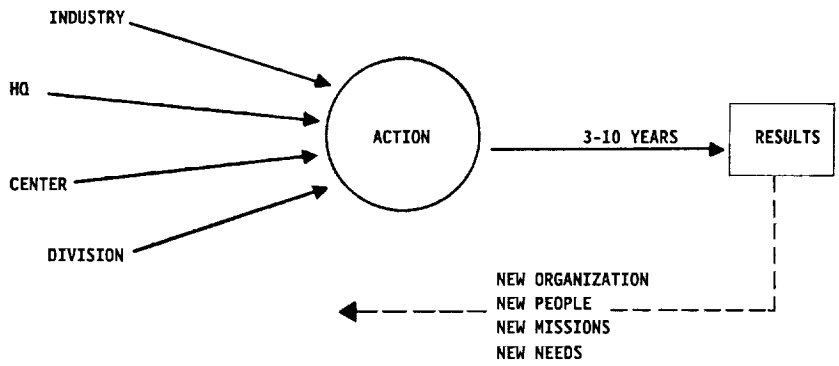


FIGURE 3.

THE R&T SELECTION PROCESS



EXAMPLE: CONSERVATION OF STRATEGIC MATERIALS

FIGURE 4.

DIFFERENT CUSTOMERS -- DIFFERENT MEASURES OF SUCCESS

RESEARCH CUSTOMERS	TECHNOLOGY
• PEERS ARE PRIMARY CUSTOMERS	• NASA/DOD/INDUSTRY CUSTOMERS
• NEW IDEAS/UNDERSTANDING & PUBLICATIONS ARE PRIMARY OUTPUT	• PREDICTIVE MODELS OR NEW MATERIALS/PROCESSES ARE OUTPUT
• SELF-GENERATED SCHEDULES AND HIGH UNCERTAINTY OF RESULTS	• SCHEDULE CUSTOMER-DRIVEN AND NEEDED RESULTS MORE CLEARLY DEFINED
• SPIN-OFF TO FOCUSED TECHNOLOGY EFFORT	

FIGURE 5.

TO IMPROVE OUR QUALITY, WE TRIED TO CHANGE THE CULTURE AND

-- EMPHASIZED QUALITY OF OUTPUT
- RESULTS OF IMPORTANCE TO INDUSTRY/HEADQUARTERS
- JOURNAL ARTICLES VS. IN-HOUSE REPORTS
- DEFINED FACTORS IMPORTANT TO REPORT QUALITY
  - MEASURE ONGOING BASIS

-- EMPHASIZED QUALITY OF STAFF
- INCREASE GRADUATE DEGREE HIRES
- EMPHASIZE SELF-DEVELOPMENT

-- EMPHASIZED QUALITY OF FACILITIES
- ONGOING UPGRADE OF LABORATORIES EQUIPMENT
- SELECTED NATIONALLY-UNIQUE CAPABILITIES

-- EMPHASIZED QUALITY OF MANAGEMENT
- PARTICIPATIVE MANAGEMENT AND TEAMWORK
- SUBORDINATE ASSESSMENT OF MANAGER PERFORMANCE

FIGURE 6.

MATERIALS DIVISION
CUSTOMER FEEDBACK SOLICITATION

- WHAT TWO THINGS HAVE WE DONE IN 1988 THAT HAVE BEEN OF MOST USE TO YOU?

  WHY?

- WHAT TWO THINGS COULD WE FOCUS ON IN 1989 THAT WOULD BE OF MOST USE TO YOU?

  WHY?

- WHAT LONGER RANGE RESEARCH ISSUES WOULD YOU LIKE US TO EXPLORE INTERNALLY TO MOST HELP YOUR ORGANIZATION?

  WHY?

FIGURE 7.

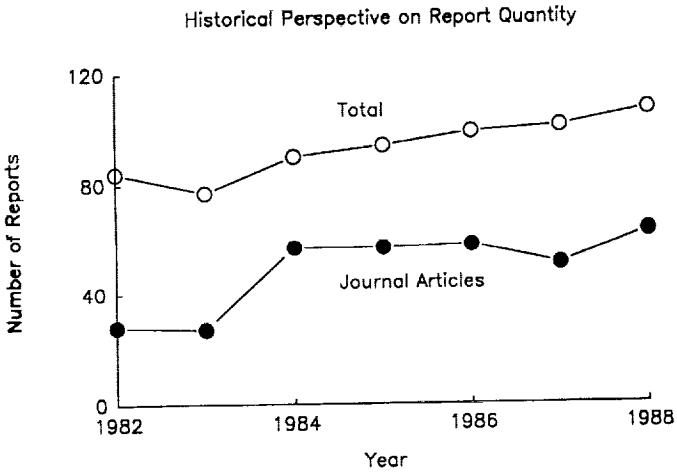


FIGURE 8.

MATERIALS DIVISION

QUALITY OF PUBLICATIONS

Title:

Author(s):
Date In: Date Out: Evaluator:

Score range in each single box is 1 to 5.
5=Outstanding 4=Very Good 3=Good 2=Marginal 1=Inadequate
Each double box is total of the three single boxes below it.

OVERALL SCORE
(total of the three double boxes)

QUALITY OF RESEARCH

PREPARATION
Purpose of the work: worthwhile? relevant to NASA? well defined at the start of the of work?
Literature survey: is it relevant? is it adequate?

APPROACH
Materials: proper for work? adequately characterized?
Equipment: proper for the job? properly calibrated? properly operated?

RESULTS
Data: relevant to objective? enough? valid? reproducible?
Interpretation: correlations sought and identified? cause and effect relations proposed? distinction between correlation and cause/effect realized?
mechanisms proposed? was objective met?

QUALITY OF WRITING

OPENING
Title descriptive?
Abstract descriptive?
Introduction: relevant, adequate, clear?
Objective explicitly stated?

BODY
Methods clear?
Quality figures and tables?
Logical development of result and discussion?
Results compared to literature?
Results interpreted objectively?

ENDING
Conclusions: significant? supported by data? relevant to objective?
Significance of work explicitly clear?
Future directions suggested?
Entire paper well organized, easy to read, good transitions, concise?

POTENTIAL IMPACT

NASA LeRC & HDQR
Strong interest at LeRC, Hdqr, other centers, other agencies?
Does it address a specific NASA problem?

AEROSPACE PROPULSION/ POWER INDUSTRY
New material/process?
Lower cost, longer life?
Patentable?
Likely to be used?

MATERIAL SCIENCE/ENGR COMMUNITY
New insight, concept, interpretation, model?
Attract attention outside of power/propulsion community?
Likely to become long term standard reference?

FIGURE 9.

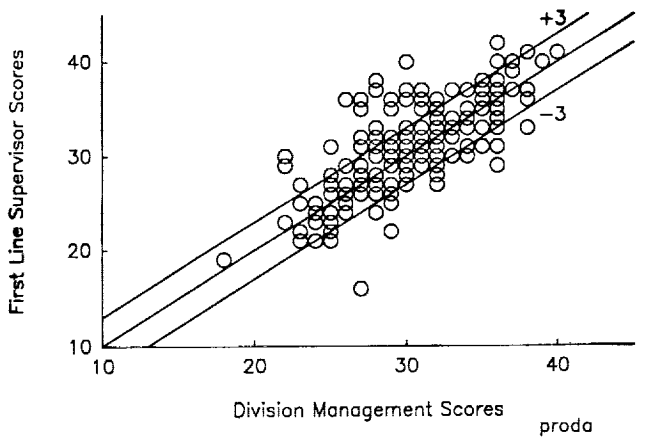


FIGURE 10.

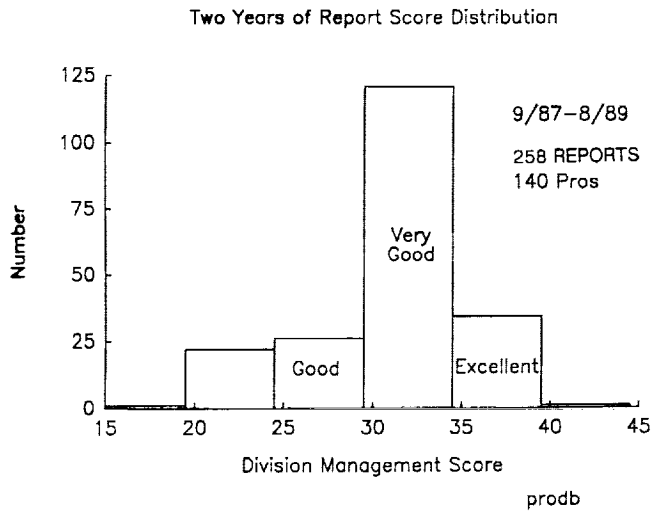


FIGURE 11.

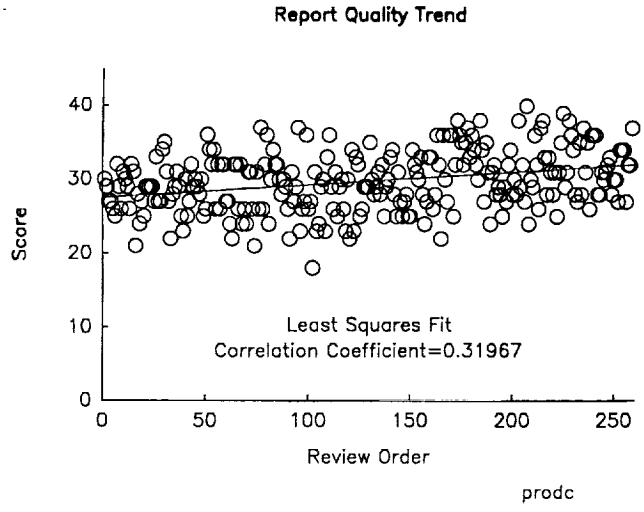


FIGURE 12.

PROFESSIONAL STAFF SKILL MIX

	BS	MS	PhD
ALL STAFF	39	39	63
SINCE 1983	15	35	50

FIGURE 13.

TOWARD A STRONGER MATERIALS DIVISION MENTOR PROGRAM

CONDITIONS

- TOP RESEARCHER (OR PROJ. MGR./SUPPORT PERSON/ETC.) SELECTED FOR MENTOR POOL -- MENTORS ARE A SPECIAL CLASS -- BOTH TASK AND PEOPLE ORIENTED --
- FORMAL ASSIGNMENT FOR 1-3 YEARS -- 1 OR 2 MAX. INDIVIDUALS PER MENTOR
- CMR ON PERFORMANCE PLAN
- REDUCE LOAD OF UNPALATABLE WORK
- QI/SSP/SAA POTENTIAL ON COMPLETION
- CO-AUTHORSHIP ON FIRST PAPER

FIGURE 14.

CONDITIONS, CONTD

- MENTOR RESPONSIBILITIES: TO UNCOVER AND/OR DEVELOP STARS -- MAXIMIZE ALL NEW STAFFER CAREERS

- 70% GROWTH VIA OJT ; --LEARN BY DOING -- --ASSIGN JOBS TO FILL GAPS & STRENGTHEN WEAK AREAS • B.C.+ MENTOR INVOLVED	20% GROWTH VIA ; FORMAL TRAINING --GRAD SCHOOL, SHORT COURSES, ETC. • B.C.+ MENTOR INVOLVED	10% VIA MENTORING --LEARN FROM OTHERS EXPERIENCE • MENTOR --HOW TO GET THINGS DONE --REPORTING/PRESENTING --HOW TO PLAN YOUR WORK --HOW TO DO LIT. SEARCH --HOW TO DESIGN EXPERIMENTS

FIGURE 15.

MENTOR SELECTION BY NEW STAFFER

- BRANCH CHIEF IDENTIFY POTENTIAL MENTORS
- NEW PERSON DISCUSS POTENTIAL RESEARCH WITH ALL OF BRANCH
- DEVELOP A SHORT LIST OF POTENTIAL MENTORS IN FIRST MONTH
- DISCUSS WITH B.C.
- REQUEST MENTOR -- BUT CHANGE IF IT DOESN'T WORK

FIGURE 16.

CAREER REVIEW

NAME:_____

YEAR:_____

MY MAJOR CONTRIBUTIONS TO NASA/U.S. NEEDS

MAJOR TRAINING TAKEN

MAJOR JOB EXPERIENCES

WHERE I'D LIKE MY CAREER TO GO:	ACTIONS I MUST TAKE	HELP I NEED FROM MGMT.
IN 2 YEARS		
IN 5 YEARS		
IN 10 YEARS		

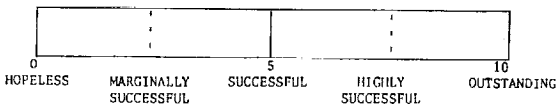
FIGURE 17.

BRANCH 51 0

MATERIALS DIVISION
1988

- GENERAL ASPECTS OF THE WAY THE DIVISION RUNS

MAJOR PROBLEMS YOU SEE:

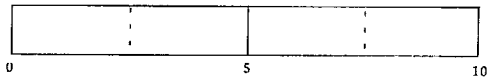


PROGRESS YOU SEE:

COULD IMPROVE BY: _____

- TECHNOLOGICAL LEADERSHIP

MAJOR PROBLEMS YOU SEE:

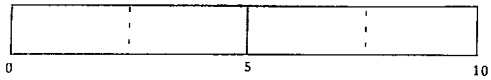


PROGRESS YOU SEE:

COULD IMPROVE BY: _____

- INSTITUTIONAL HEALTH

MAJOR PROBLEMS YOU SEE:



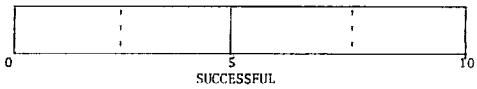
PROGRESS YOU SEE:

COULD IMPROVE BY: _____

FIGURE 18.

- EXTERNAL IMAGE

MAJOR PROBLEMS YOU SEE:



PROGRESS YOU SEE:

COULD IMPROVE BY: _____

YOUR JOB
THINGS THAT HAVE HAPPENED THIS YEAR WHICH IMPROVED YOUR ABILITY TO DO A SOLID JOB ARE:

THINGS THAT STILL GET IN YOUR WAY TO ACCOMPLISH YOUR JOB:

YOU
- THINGS YOU DID THIS YEAR TO BUILD YOUR SKILLS/DEVELOP YOUR CAREER ARE:

- THINGS YOU'D LIKE THE DIVISION TO DO IN '89 TO BUILD YOUR SKILLS/DEVELOP YOUR CAREER:

OTHER SUGGESTIONS/COMMENTS: (USE BACK OF THIS PAGE)

FIGURE 19.

RATE YOUR SUPERVISOR !

SUPERVISOR_____ORG. CODE_____

Branch chiefs and their deputies in the Materials Division are seriously interested in obtaining your perception of their effectiveness as a manager. This questionnaire is a means of obtaining information that will assist them in improving their performance, both actual and perceived. You are requested to assess your supervisor's effectiveness in three general areas: Technical Direction, Organizational and Personal. Each area has subcategories which encompass responsibilities of supervisors. Please rate your supervisor(s) for each question and assign a ranking to each in terms of how important the implicit aspects included in each question are to you. You are also encouraged to include specific individual comments. Anonymity is requested. Results will be shared by the division chief and respective supervisors.

Rating: 1=Good 2=Average 3=Poor
Importance: 1=High 2=Medium 3=Low

	Rating	Importance
TECHNICAL DIRECTION		
1. Possesses adequate understanding of technology in area he/she manages.		
2. Formulates overall technical program and goals for the Branch.		
3. Provides adequate technical input to the Branch effort.		
4. Solicits your input.		
ORGANIZATIONAL		
5. Obtains funding, equipment, space and personnel to carry out technical programs of the Branch.		
6. Interacts effectively with upper management.		
7. Acts as effective buffer between you and upper management.		
8. Sets up teams to accomplish technical goals.		
9. Fosters communications within Branch.		
10. Provides timely support to address organizational, personal, etc, problems.		
11. Solicits your input.		

FIGURE 20.

PERSONAL		
12. Aids in achieving your career goals.		
13. Advocates promotions and awards when warranted.		
14. Aids in formulating performance plans and provides helpful feedback.		
15. Is approachable and willing to communicate on individual basis.		
16. Is fair and evenhanded in dealing with Branch members.		
17. Solicits your input.		

Please indicate your perception of the amount of time your supervisor devotes to each major category together with what you think would be an ideal allocation of their time.

	Perceived % Time	Ideal % Time
18. TECHNICAL DIRECTION		
19. ORGANIZATIONAL		
20. PERSONAL		

SPECIFIC COMMENTS (continue on separate sheet if desired)

SUGGESTIONS TO IMPROVE THIS QUESTIONNAIRE OR THIS EXERCISE

FIGURE 21.

Volume 8, Number 3 September 1988

Ultra-high-temperature metals research

Lewis Research Center is the hub of the NASA Advanced High Temperature Engine Materials Program. Other significant efforts are being conducted at the AFWAL Aero Propulsion and Materials Laboratories. DOE's Oak Ridge National Laboratory and Los Alamos National Laboratory are involved in developing intermetallics and beryllides and modeling their physicochemical characteristics, respectively. DARPA is sponsoring advanced programs on intermetallics with emphasis on a titanium aluminide program and a copper niobium microcomposite program. Numerous contractors and universities are pursuing high-temperature materials programs.

NASA-Lewis MMC Programs

Metal matrix composites research and development at NASA-Lewis Research Center focuses on advanced high-temperature materials for future aerospace propulsion and power systems. Many of the continuous fiber-reinforced metal matrix composites fabricated at NASA-Lewis utilize its arc-spray monotape fabrication process (described in the March 1987 issue of *Current Highlights*). A major emphasis has been on the development of tungsten-fiber-reinforced superalloys to improve creep properties and increase allowable operating temperatures for turbine blade and vane applications in aircraft engines. A significant factor with fiber-reinforced superalloys is the prevention of fiber/matrix interaction, which could degrade the properties of the reinforcing fiber. In the worst case, the fiber and matrix react during high-temperature fabrication or service, forming brittle intermetallic compounds or degrading the fiber. It has also been found that conventional nickel-base superalloys can cause a diffusion-triggered recrystallization within the tungsten wire, causing the fiber to lose its strength and ductility with time. To reduce these degradation reactions, modified FeCrAlY superalloys are being used as a matrix material because iron-base alloys have much better compatibility with the tungsten fiber and provide an oxidation-resistant, high thermal conductivity, ductile matrix to complement the properties

FIGURE 22.

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National Aeronautics and Space Administration

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16. Abstract

The Materials Division at NASA's Lewis Research Center has been engaged in a program to improve the quality of its output. This paper describes the division, its work, and its customers as well as the methodologies developed to assess and improve the quality of the Division's staff and output. Examples of these methodologies are presented and evaluated. The report concludes with an assessment of current progress and a summary of future plans.

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